PRIVATE AND CONFIDENTIAL

RESEARCH DEPARTMENT

TELEVISION TRANSMITTERS - SITE TESTS IN CUMBERLAND

Report No. K-108

(1956/8)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

TELEVISION TRANSMITTERS - SITE TESTS IN CUMBERLAND

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(1956/8)

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TELEVISION TRANSMITTERS - SITE TESTS IN CUMBERLAND

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TELEVISION TRANSMITTERS——SITE TESTS IN CUMBERLAND

SUMMARY

Two sites, Warnell Fell and Sandale Fell, have been tested in Cumberland. Sandale Fell provided much the better site, particularly in respect of a service to the populated coastal strip of Cumberland, and this report accordingly recommends that the transmitter be sited at Sandale Fell.

The television distribution plan provides for a low power transmitter in Cumberland. The merit of the two sites was therefore originally based on a comparison of the service obtained with an e.r.p. of 0·6-1·5 kW. It was later decided to provide Cumberland with a medium power transmitter, with an e.r.p. of 12-30 kW.

Reception tests showed that Kirk o' Shotts would provide the strongest and most reliable signal for a R.B.R. link. The vision signal from Pontop Pike may also be strong enough for a reasonable R.B.R. service, should direct pick-up of Kirk o' Shotts be impracticable through interference from the adjacent sound channel of the local transmitter.

1. INTRODUCTION.

The tests described were undertaken to determine the best site for a low power television transmitter to serve the Carlisle area, north and north-west Cumberland and the southern areas of Kirkcudbrightshire and Dumfriesshire, these areas being outside the reliable range of any existing television service.

It was also desirable that the site would be suitable as a pick-up point for relaying the vision signal direct from either Holme Moss, Kirk o' Shotts or Pontop Pike.

2. GENERAL.

In the television transmitter distribution plan, Channel 4 (61·75 Mc/s) is allocated to the Cumberland area, with horizontal polarisation. It was proposed to use a two-tier batwing-V transmitting aerial with the horizontal radiation pattern shown in Fig. 1.

The test transmissions were radiated on Channel 4 from a half-wave dipole mounted on either a 110 ft (33·5 m) mast or a balloon flying at various heights up to a maximum of 550 ft (167·6 m).

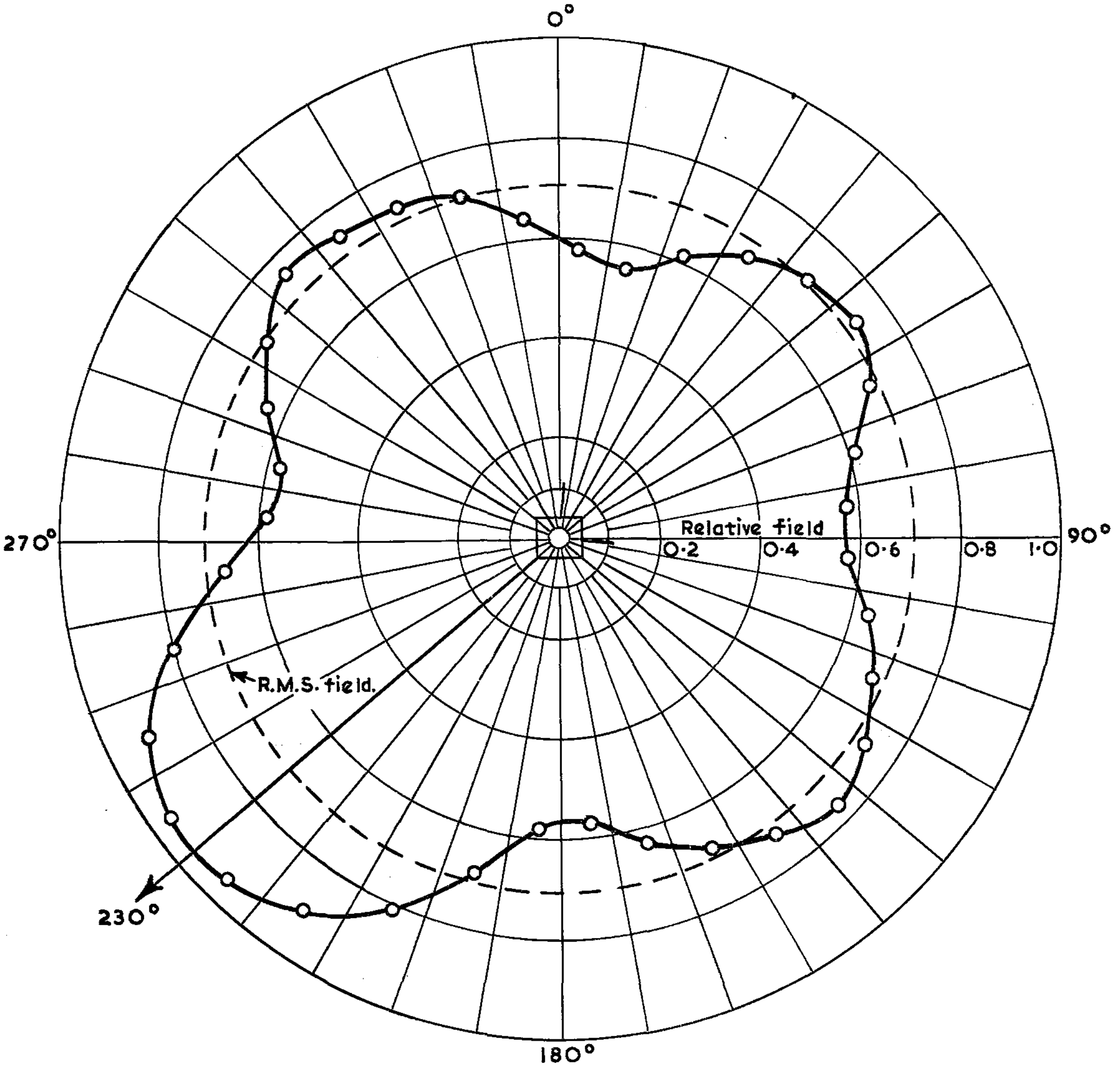

Fig. 1 - H.R.P. of the two-tier batwing-V aerial (Channel 4)

The transmitting aerials used for the tests were omnidirectional and the receiving aerial was 15 ft (4·6 m) above ground level. All field strengths quoted in this report have however been corrected to apply to radiation from a horizontal batwing-V aerial 415 ft (126 m) above ground level oriented for maximum radiation in the direction of Whitehaven and for a receiving aerial height of 30 ft (9·2 m) above ground level.

The field strengths of the Holme Moss, Kirk o' Shotts and Pontop Pike television transmissions were recorded for some time on both sites on receiving aerials 30 ft (9·2 m) above ground. Height-gain measurements were made in order to determine the optimum aerial height for the reception of these respective transmissions.

Particulars of the two sites are summarised in the Appendix.

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Note:
The contours represent field strength in mV/m at 30 ft above ground exceeded at 50% of receiving sites in a given locality. The value exceeded at 90% of receiving sites may be as much as 10 dB below the value indicated by the contours, particularly in hilly and built-up areas.

✕–✕–✕ Limit of service area free from perceptible interference from co-channel transmitters for 90% of the time.

Population within	
0·1mV/m:	298,700.
0·5mV/m:	164,400.
5 mV/m:	12,900.

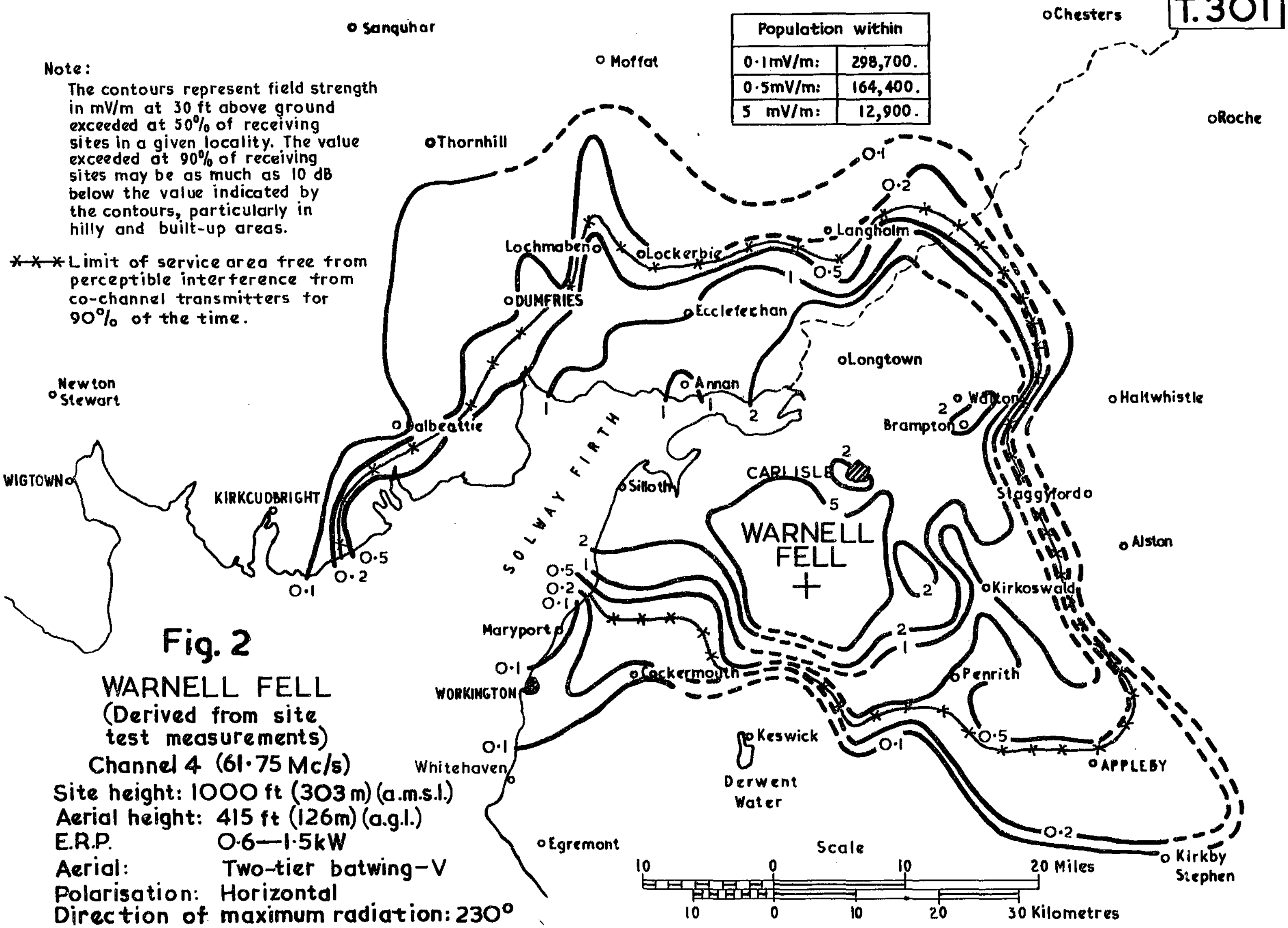

Fig. 2

WARNELL FELL
(Derived from site test measurements)
Channel 4 (61·75 Mc/s)

Site height: 1000 ft (303 m) (a.m.s.l.)
Aerial height: 415 ft (126m) (a.g.l.)
E.R.P. 0·6—1·5kW
Aerial: Two-tier batwing–V
Polarisation: Horizontal
Direction of maximum radiation: 230°

Note:
The contours represent field strength in mV/m at 30 ft above ground exceeded at 50% of receiving sites in a given locality. The value exceeded at 90% of receiving sites may be as much as 10 dB below the value indicated by the contours, particularly in hilly and built-up areas.

✱—✱—✱ Limit of service area free from perceptible interference from co-channel transmitters for 90% of the time.

Population within	
0·1 mV/m:	345,500.
0·5 mV/m:	224,600.
5 mV/m:	22,900.

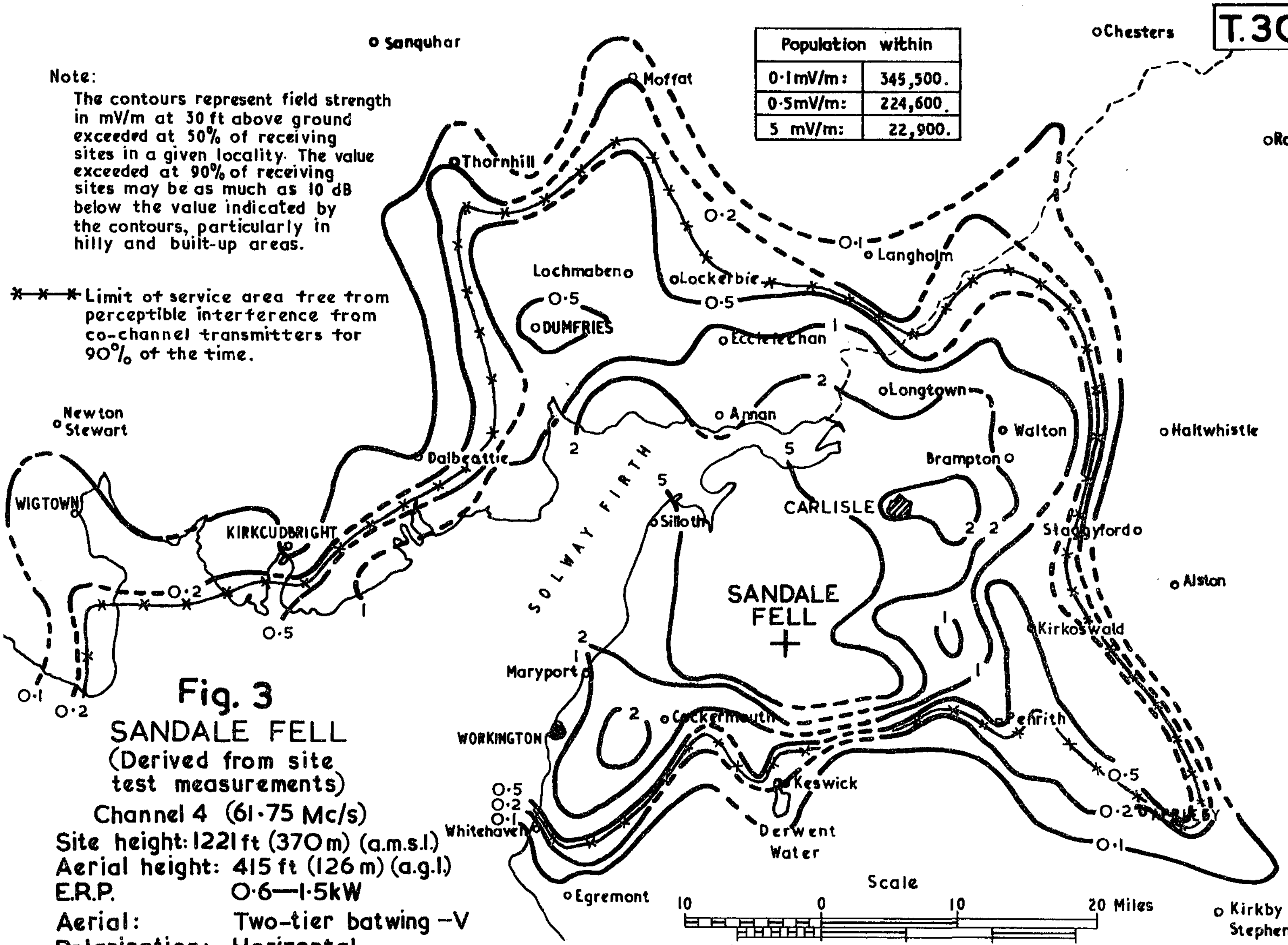

Fig. 3

SANDALE FELL
(Derived from site test measurements)
Channel 4 (61·75 Mc/s)
Site height: 1221 ft (370 m) (a.m.s.l.)
Aerial height: 415 ft (126 m) (a.g.l.)
E.R.P. 0·6—1·5 kW
Aerial: Two-tier batwing -V
Polarisation: Horizontal
Direction of maximum radiation: 230°

3. RESULTS.

3.1. Low Power Transmitter (0·6–1·5 kW)

The field strength in the principal towns for each site is given in Table 1; a field strength contour map for each site is shown in Figs. 2 and 3.

TABLE 1

Field Strength in mV/m 30 ft (9·2 m) a.g.l.
0·5 kW Transmitter E.R.P. = 0·6–1·5 kW
2-tier batwing-V aerial 415 ft (126 m) a.g.l.

Town	Warnell Fell			Sandale Fell		
	Max.	Mean	Min.	Max.	Mean	Min.
Annan	2·7	0·9	0·27	3·8	1·1	0·29
Appleby	1·3	0·4	0·1	0·8	0·18	0·06
Brampton	2·0	0·7	0·27	4·2	1·3	0·31
Carlisle	9·5	1·9	0·46	8·0	1·8	0·36
Castle Douglas	0·32	0·08	0·03	0·28	0·12	0·05
Cockermouth	0·26	0·11	0·02	5·6	1·2	0·2
Dalbeatie	0·06	0·04	0·03	0·22	0·08	0·04
Dumfries	0·63	0·16	0·06	0·9	0·25	0·09
Keswick	0·06	0·04	0·03	0·82	0·2	0·03
Kirkcudbright	0·05	0·03	0·02	0·07	0·03	0·01
Langholm	0·46	0·16	0·05	0·41	0·11	0·04
Lockerbie	1·7	0·42	0·15	0·85	0·4	0·12
Longtown	4·0	1·8	0·8	1·9	1·0	0·54
Maryport	0·1	0·04	0·03	2·7	0·9	0·27
Moffat	0·11	0·06	0·04	0·43	0·19	0·06
Penrith	3·5	0·45	0·05	0·9	0·5	0·09
Whitehaven	0·12	0·05	0·04	0·42	0·1	0·04
Wigtown	0·14	0·06	0·03	0·27	0·14	0·05
Workington	0·39	0·11	0·03	5·6	0·75	0·25

Population coverage figures have been evaluated by B.B.C. Engineering Information Department for both sites with the following result:

	Population receiving a field strength greater than		
	0·1 mV/m	0·5 mV/m	5 mV/m
Warnell Fell	298,700	164,400	12,900
Sandale Fell	345,500	224,600	22,900

3.1.1. Warnell Fell.

The most disappointing feature of this site is the extremely low field strength in the industrial towns of Maryport (0·04 mV/m), Whitehaven (0·05 mV/m) and Workington (0·11 mV/m). These relatively highly populated towns would not receive a service. Carlisle with 1·9 mV/m and Penrith with 0·45 mV/m should both have an adequate service but the contour map (Fig. 2) shows that most of the Lake District is outside the service area. The southern half of Dumfriesshire would be quite well served but 0·16 mV/m in Dumfries itself is too low. Only the extreme south-east corner of Kirkcudbrightshire will be served.

3.1.2. Sandale Fell

From Table 1 it can be seen that both Maryport (0·9 mV/m) and Workington (0·75 mV/m) would be quite well served, but Whitehaven (0·1 mV/m) would have only a fringe area service. Carlisle (1·8 mV/m) and Penrith (0·5 mV/m) would be adequately served. Comparison of the two sites shows Sandale Fell would give a greatly improved service in the northern areas of the Lake District, and Keswick (0·2 mV/m) would receive an improved signal.

Dumfries, with a mean field strength of 0·25 mV/m would receive an improved service and most of southern Dumfriesshire and Kirkcudbrightshire would be inside the 0·1 mV/m contour.

3.2. The Service provided by a Medium Power Transmitter at Sandale Fell (E.R.P. 12–30 kW)

Because of the poor service in Whitehaven and the Lake District noted in the previous paragraph it has now been decided to use a medium power transmitter (5 kW) at Sandale Fell. Table 2 makes direct comparison of the field strength in the principal towns for the following conditions:

i. the original proposal for a low power transmitter (0·5 kW) driving a two–tier batwing–V aerial;

ii. a compromise proposal to use a low power transmitter (0·5 kW) driving a four–tier batwing–V aerial; and

iii. a 5 kW transmitter driving a four–tier batwing–V aerial.

TABLE 2

Field Strength in mV/m 30 ft (9·2 m) a.g.l.

Town	2–tier batwing–V 0·5 kW transmitter (E.R.P. 0·6–1·5 kW)			4–tier batwing–V 0·5 kW transmitter (E.R.P. 1·2–3 kW)			4–tier batwing–V 5 kW transmitter (E.R.P. 12–30 kW)		
	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.
Annan	3·8	1·1	0·3	5·4	1·6	0·43	17·0	4·9	1·3
Appleby	0·8	0·18	0·06	1·1	0·25	0·09	3·5	0·8	0·27
Brampton	4·2	1·3	0·31	6·0	1·8	0·44	19·0	5·7	1·4
Carlisle	8·0	1·8	0·36	11·0	2·5	0·5	35·0	8·0	1·6
Castle Douglas	0·28	0·12	0·05	0·4	0·17	0·07	1·3	0·53	0·22
Cockermouth	5·6	1·2	0·2	8·0	1·7	0·28	25·0	5·3	0·9
Dalbeatie	0·22	0·08	0·04	0·31	0·11	0·05	1·0	0·35	0·16
Dumfries	0·9	0·25	0·09	1·3	0·35	0·13	4·1	1·1	0·41
Keswick	0·82	0·2	0·03	1·1	0·3	0·04	3·5	1·0	0·12
Kirkcudbright	0·07	0·03	0·01	0·1	0·04	0·02	0·31	0·14	0·05
Langholm	0·41	0·11	0·04	0·58	0·16	0·06	1·8	0·49	0·18
Lockerbie	0·85	0·4	0·12	1·2	0·56	0·17	3·8	1·8	0·57
Longtown	1·9	1·0	0·54	2·7	1·41	0·77	8·5	4·5	2·4
Maryport	2·7	0·9	0·27	3·8	1·3	0·38	12·0	4·0	1·2
Moffat	0·43	0·19	0·06	0·61	0·27	0·08	1·9	0·9	0·25
Penrith	0·9	0·5	0·09	1·3	0·7	0·13	4·1	2·2	0·41
Whitehaven	0·42	0·1	0·04	0·6	0·14	0·06	1·9	0·45	0·17
Wigtown	0·27	0·14	0·05	0·38	0·2	0·07	1·2	0·63	0·22
Workington	5·6	0·75	0·25	8·0	1·1	0·35	25·0	3·5	1·1

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Note:
The contours represent field strength in mV/m at 30 ft above ground exceeded at 50 % of receiving sites in a given locality. The value exceeded at 90% of receiving sites may be as much as 10 dB below the value indicated by the contours, particularly in hilly and built up areas.

-x-x-x- Limit of service area free from perceptible interference from co-channel transmitters for 90% of the time.

Population within	
0·1mV/m:	358,200.
0·5mV/m:	252,800.
5 mV/m:	32,400.

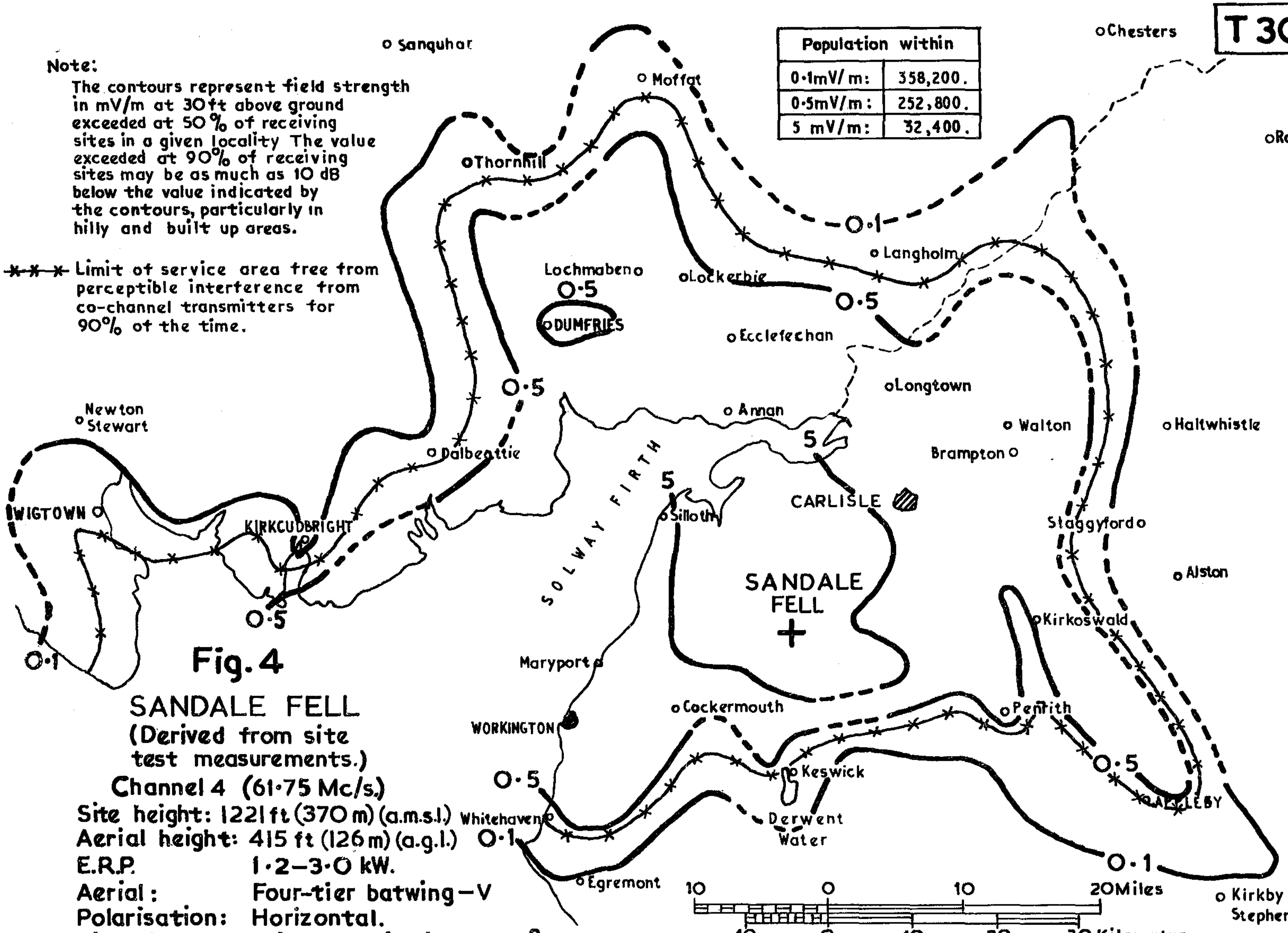

Fig. 4

SANDALE FELL
(Derived from site test measurements.)
Channel 4 (61·75 Mc/s.)
Site height: 1221 ft (370 m) (a.m.s.l.)
Aerial height: 415 ft (126 m) (a.g.l.)
E.R.P. 1·2–3·0 kW.
Aerial: Four-tier batwing–V
Polarisation: Horizontal.
Direction of maximum radiation: 230°

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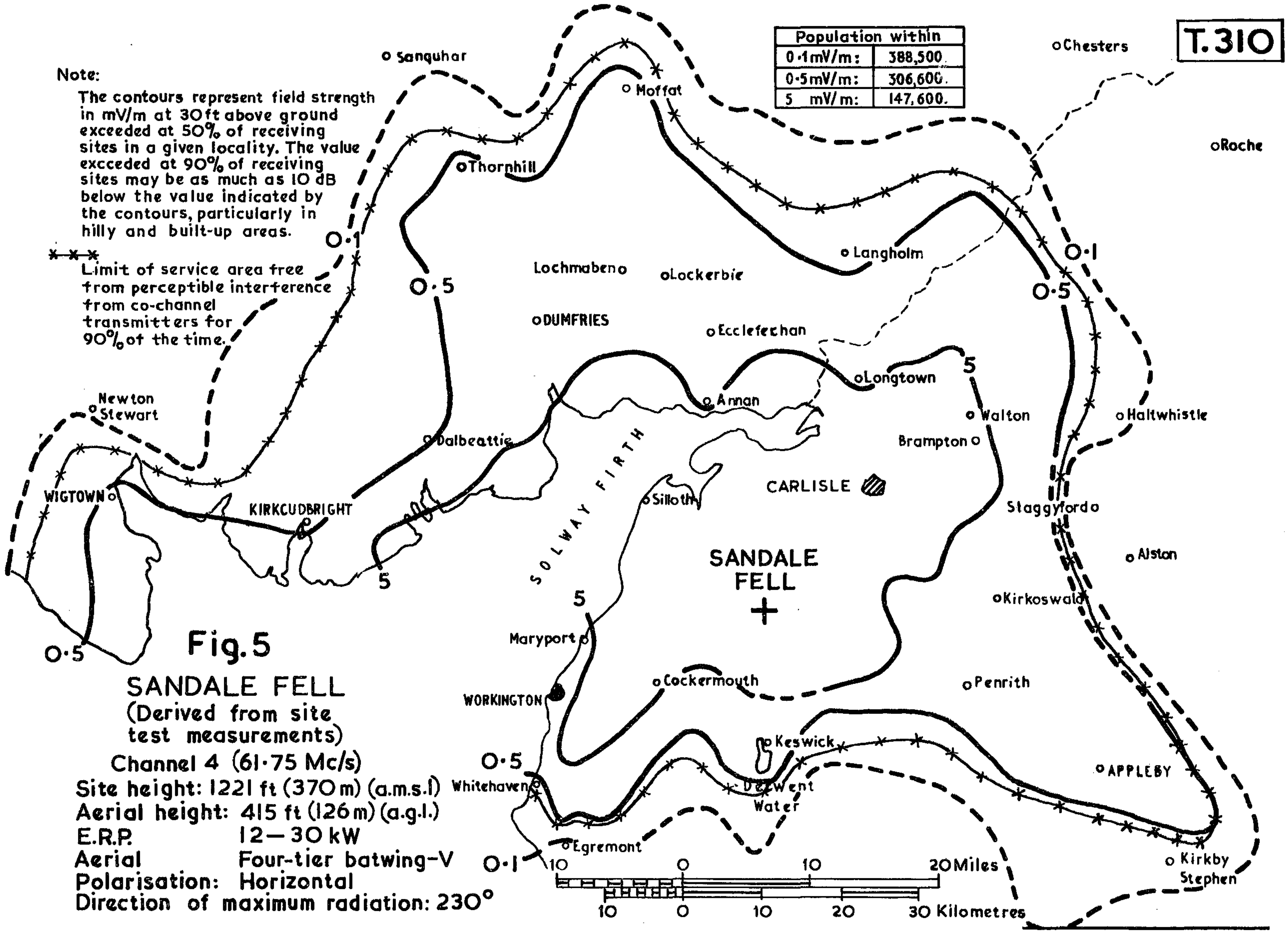

Note:

The contours represent field strength in mV/m at 30 ft above ground exceeded at 50% of receiving sites in a given locality. The value exceeded at 90% of receiving sites may be as much as 10 dB below the value indicated by the contours, particularly in hilly and built-up areas.

×—×—× Limit of service area free from perceptible interference from co-channel transmitters for 90% of the time.

Population within	
0·1 mV/m:	388,500.
0·5 mV/m:	306,600.
5 mV/m:	147,600.

Fig. 5

SANDALE FELL
(Derived from site test measurements)

Channel 4 (61·75 Mc/s)

Site height: 1221 ft (370 m) (a.m.s.l)
Aerial height: 415 ft (126 m) (a.g.l.)
E.R.P. 12—30 kW
Aerial Four-tier batwing-V
Polarisation: Horizontal
Direction of maximum radiation: 230°

Field strength contours for these conditions are shown in Figs. 3, 4 and 5 respectively and the population figures for the 5, 0·5 and 0·1 mV/m contours are given in Table 3.

TABLE 3

Field Strength 30 ft (9·2 m) a.g.l. (mV/m)	Population within 5, 0·5 and 0·1 mV/m Contours for an Aerial elevated 415 ft (126 m) a.g.l. at Sandale Fell		
	e.r.p. 0·6–1·5 kW	e.r.p. 1·2–3 kW	e.r.p. 12–30 kW
5·0	22,900	32,400	147,600
0·5	224,600	252,800	306,600
0·1	345,500	358,200	388,500

The major advantage of increasing the transmitter power at Sandale Fell is to increase, by 115,000, the population receiving 5 mV/m or better and by about 50,000 the population receiving 0·5 mV/m or better. At the normal limit of the service area, 0·1 mV/m, the table shows only a small increase of coverage with the higher power. Co-channel interference from the other transmitters sharing the channel (Sutton Coldfield and Meldrum), will in any case limit the service area of the Sandale Fell transmitter to a value in excess of 0·1 mV/m. The substantial increase of coverage at the 0·5 mV/m level is therefore particularly important.

It should be borne in mind that an increase of power of the Cumberland transmitter to 12–30 kW will cause interference within the service area of the co-channel transmitters at Sutton Coldfield and Meldrum. The northern limits of the Sutton Coldfield service area will be subject to co-channel interference but this area is well served from Holme Moss. Co-channel interference from Sandale Fell is not therefore a cause for concern in this area. Interference may, however, be experienced in the Inverbervie–Montrose area where a field strength of 400 µV/m would be protected only for 90% of the time. Some protection from this interference will be achieved if viewers use directional aerials, since Sandale Fell lies almost directly behind an aerial directed at Meldrum.

Fig. 6 is a composite map showing the 0·1 mV/m contour for the proposed medium power transmitter at Sandale Fell and for the geographically adjacent transmitters at Kirk o' Shotts, Divis, Holme Moss, Pontop Pike and Snaefell.

3.3. Reception of the Holme Moss, Pontop Pike and Kirk o' Shotts Transmitters at Sandale Fell and Warnell Fell

The field strength of the three geographically adjacent television transmitters was recorded at Warnell Fell and Sandale Fell. Receiving aerials 30 ft (9·2 m) above ground level were used and, in general, the field strength was found to be approximately the same on both sites. Height-gain measurements to determine the optimum height for the receiving aerials were also made. The weather during the tests was very variable and therefore the results may be regarded as being reasonably representative of those which may be expected over a longer period of time.

Table 4 summarises the results of these observations made at Sandale Fell and indicates the order of field strength that may be expected for a receiving aerial elevated to the optimum height for maximum field strength.

TABLE 4

Transmitter	Channel	Distance		Period	Valid Recording Time	Field Strength measured (mV/m) 30 ft (9·2 m) a.g.l.			Optimum Receiving Aerial Height		Height Gain relative f/s 30 ft (9·2 m) a.g.l.	Probable Field Strength (mV/m) at Optimum Height		
		Miles	km		(hours)	Max.	Median	Min.	ft	m	(dB)	Max.	Median	Min.
Holme Moss	2	100	161	14.4.55– 4.5.55	86	0·14	0·09	0·04	450	137	13·2	0·63	0·41	0·18
Kirk o' Shotts	3	82·5	133	19.4.55– 4.5.55	60	1·8	1·1	0·8	60	18	2·0	2·3	1·4	1·0
Pontop Pike*	5	55·2	89	14.4.55– 6.5.55	91	0·3	0·2	0·1	–	–	–	–	–	–

*Based on field strength measurements of the temporary transmitter and aerial at Pontop Pike. Corrected for an e.r.p. of 12 kW and an aerial 475 ft (145 m) above ground level.

It should be noted that the fading was not serious and no drop-outs occurred during the tests although the path length and weather conditions were such that these could have been expected.

Only Kirk o' Shotts, with a median field strength of 1·1 mV/m provided a good picture with a receiving aerial 30 ft (9·2 m) above ground level. Maximum field strength was observed with the receiving aerial only 60 ft (18 m) above ground level, the height gain being only 2·0 dB.

The reception of Holme Moss with a 30 ft (9·2 m) receiving aerial was poor, the median and minimum field strengths during the 86 hour test period being only 0·09 mV/m and 0·04 mV/m respectively.

The height-gain observations showed, however, that by increasing the receiving aerial height from 30 ft (9·2 m) to 450 ft (137 m) the field strength increased by 13 dB. Thus, assuming that the relationship between the median and minimum field strengths is the same for both aerial heights, the median and minimum field strengths expected with a receiving aerial 450 ft (137 m) above ground level would be 0·41 mV/m and 0·18 mV/m respectively. The signal received at 450 ft (137 m) above ground level may, however, be expected to be more stable than that received at 30 ft (9·2 m), therefore the minimum value of 0·18 mV/m quoted above is probably pessimistic.

When the tests were in progress the Pontop Pike transmissions were radiated by the standby transmitter (0·5 kW) driving a temporary aerial mounted 150 ft (46 m) above ground level. The figures quoted in Table 4 have been corrected to indicate the value expected from the permanent transmitter. It was not possible to make height-gain observations because of the low field strength of the temporary transmissions and the high attenuation of the balloon feeder.

The results of these reception tests indicate that Kirk o' Shotts (56·75 Mc/s) will probably provide the strongest and perhaps the most reliable signal. The Sandale Fell sound transmission on a frequency of 58·25 Mc/s would however probably cause intolerable interference on this channel. Consideration might, however, be given to siting the Kirk o' Shotts receiver some distance (say 1 mile (1·6 km)) from Sandale Fell, and a further reduction in the interference level could then be achieved by the use of a directional receiving aerial.

In the absence of height-gain measurements it is not possible to assess the

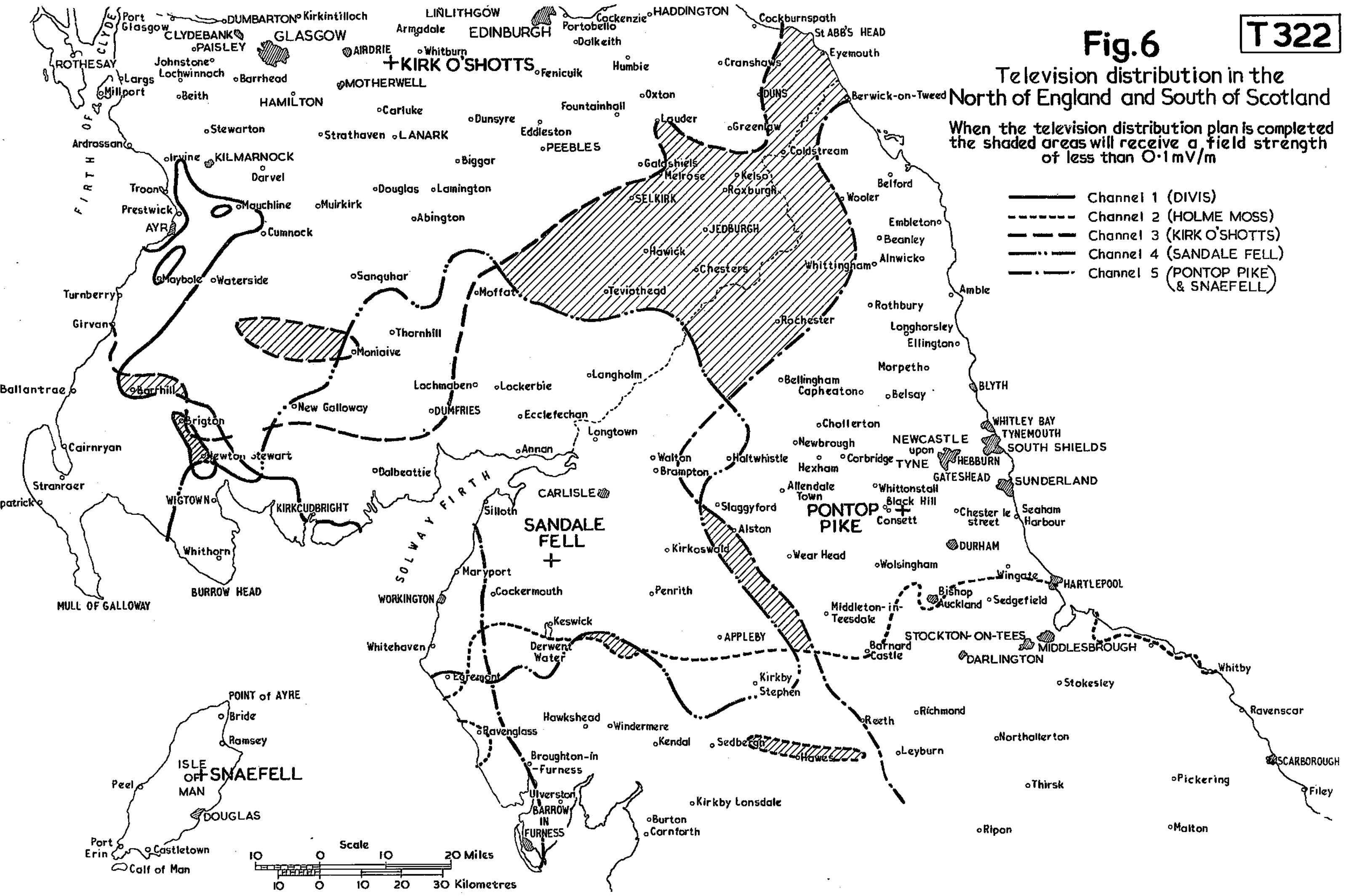

Fig.6

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Television distribution in the North of England and South of Scotland

When the television distribution plan is completed the shaded areas will receive a field strength of less than 0·1 mV/m field strength that may be expected from Pontop Pike but it is unlikely to be as great as that provided by Kirk o' Shotts.

Although no serious fading was observed on the Holme Moss transmissions, the distance involved is 100 miles (161 km), and experience indicates that drop-outs on such a long link must be expected. It appears certain that, whichever transmission proves the most practicable for R.B.R. purposes, steps will have to be taken to reduce still further the harmonics and other spurious radiation from the Skelton transmitters.

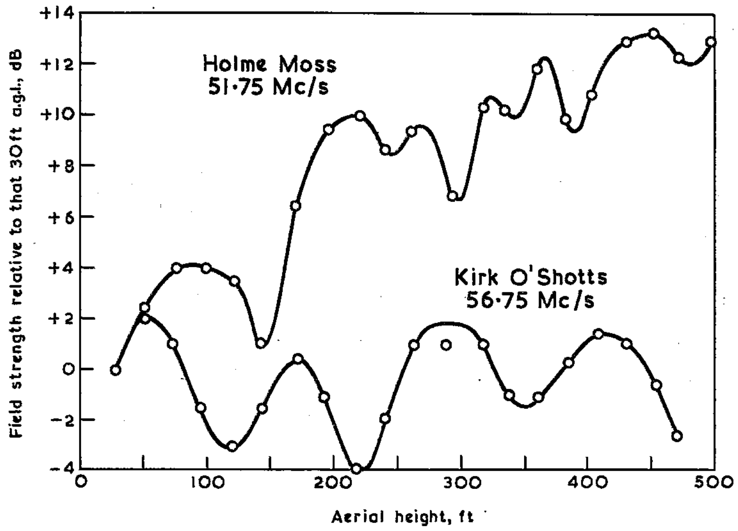

Fig. 7 - Reception height-gain measurements at Sandale Fell

Fig. 7 shows the field strength of the Kirk o' Shotts and Holme Moss transmissions plotted as a function of receiver aerial height at Sandale Fell. These curves are two examples of the results of a number of height-gain experiments. These confirm that the generally accepted statement "the higher the receiving aerial the greater the field strength" does not always hold. It is therefore recommended that the height of receiving aerials for television R.B.R. links should, as far as possible, be determined experimentally.

4. CONCLUSIONS.

Of the two sites tested Sandale Fell is the better, and it is recommended that the station be built on this site. The use of a medium power transmitter with an e.r.p. of 12–30 kW (instead of the original plan to use a low power transmitter (e.r.p. 0·6–1·5 kW)) will provide a good service to the industrial area of Cumberland, to some parts of the Lake District and to Kirkcudbrightshire and Dumfriesshire. Although Kirk o' Shotts provides the strongest signal for R.B.R. purposes it may not be possible to use this transmission because of interference from the Sandale Fell sound transmitter. The permanent transmitter at Pontop Pike may provide a strong enough signal for R.B.R. purposes; this can only be determined by a later experiment.

APPENDIX

Warnell Fell

Latitude:	54° 45′ 40″ N
Longitude:	03° 01′ 55″ W
National Grid Reference:	NY/336412
Site Height:	1000 ft (303 m) AMSL

Sandale Fell

Latitude:	54° 44′ 54″ N
Longitude:	03° 08′ 23″ W
National Grid Reference:	NY/268398
Site Height:	1221 ft (370 m) AMSL